

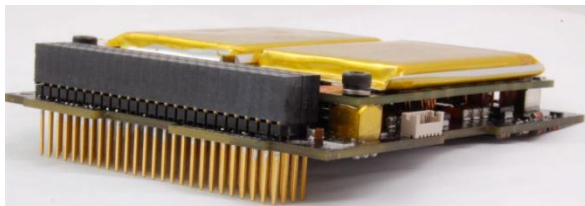
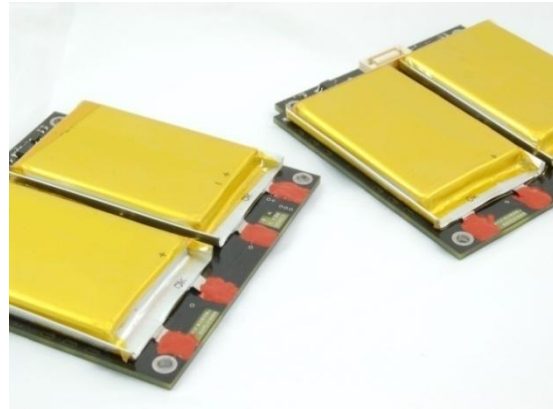
Lithium Ion Polymer Cell for Small Satellites



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What we do



Lithium Polymer Battery Study

Clyde Space won ESA funding (ITI Program) to evaluate the suitability of a COTS Lithium Polymer Cell for applications in Small Satellites

The following tests have been carried out as part of this study:

Cell Characterisation Tests

- Physical Characteristics
- Electrical Characteristics
- DPA
- Standard Capacity
- Capacity Variation with Discharge Rate and Temperature
- Capacity Variation with Depth of Discharge
- Self Discharge/Optimum Storage Condition
- Vacuum Cycling
- EMF vs. SoC

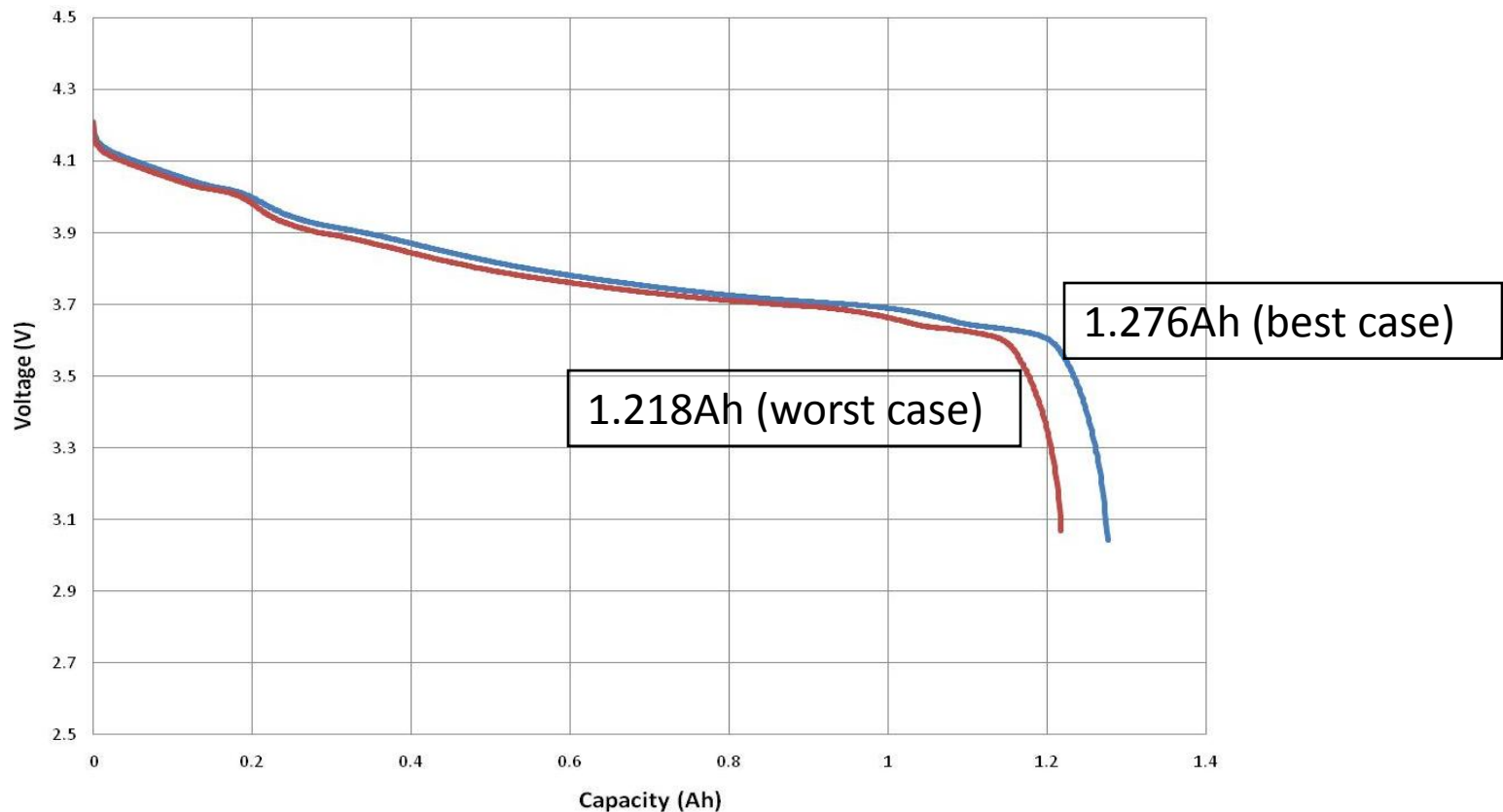
Cell Balancing and Thermal Properties

- Thermal Properties
- Balancing Properties

Cell Characterisation Tests: Standard Capacity Results



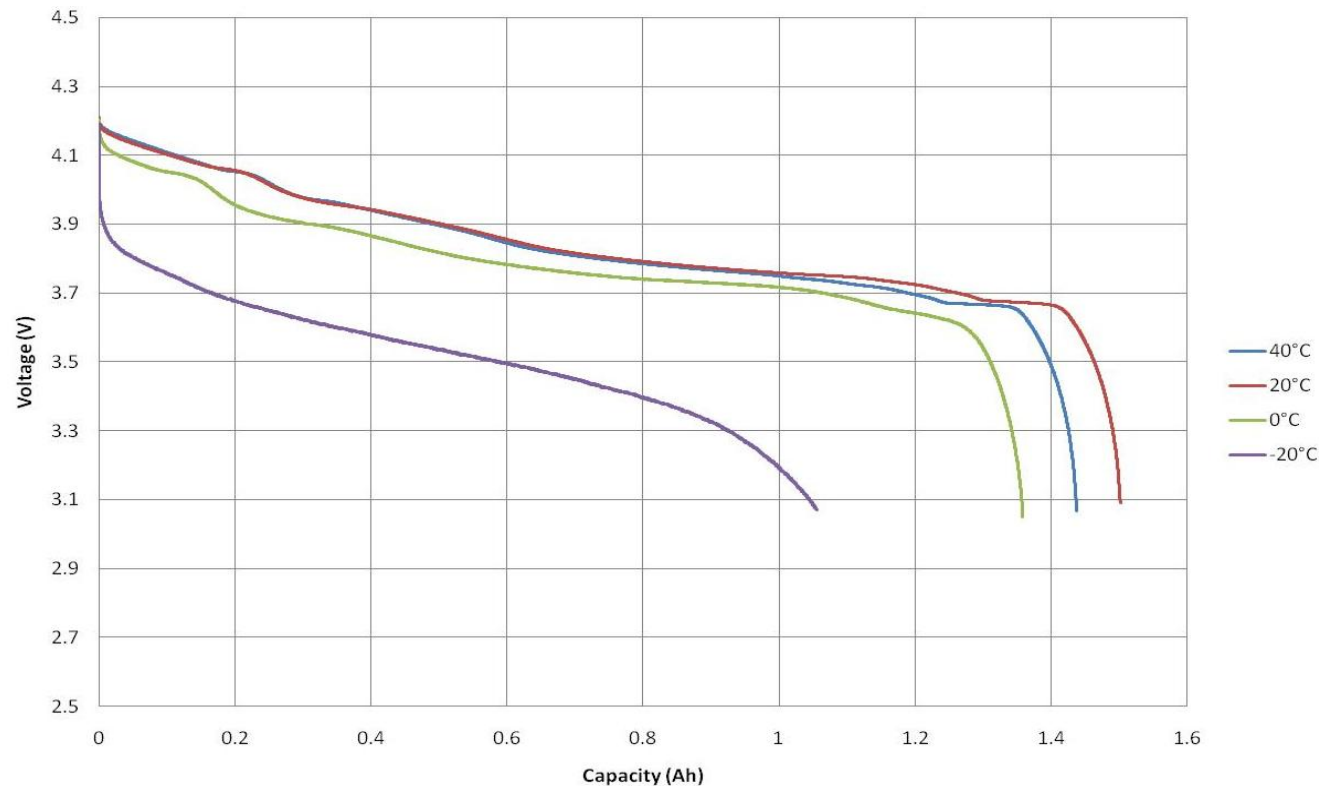
Standard Capacity measured at C/5 at 20°C



Manufacturer's Specification: Minimum Capacity = 1.200Ah

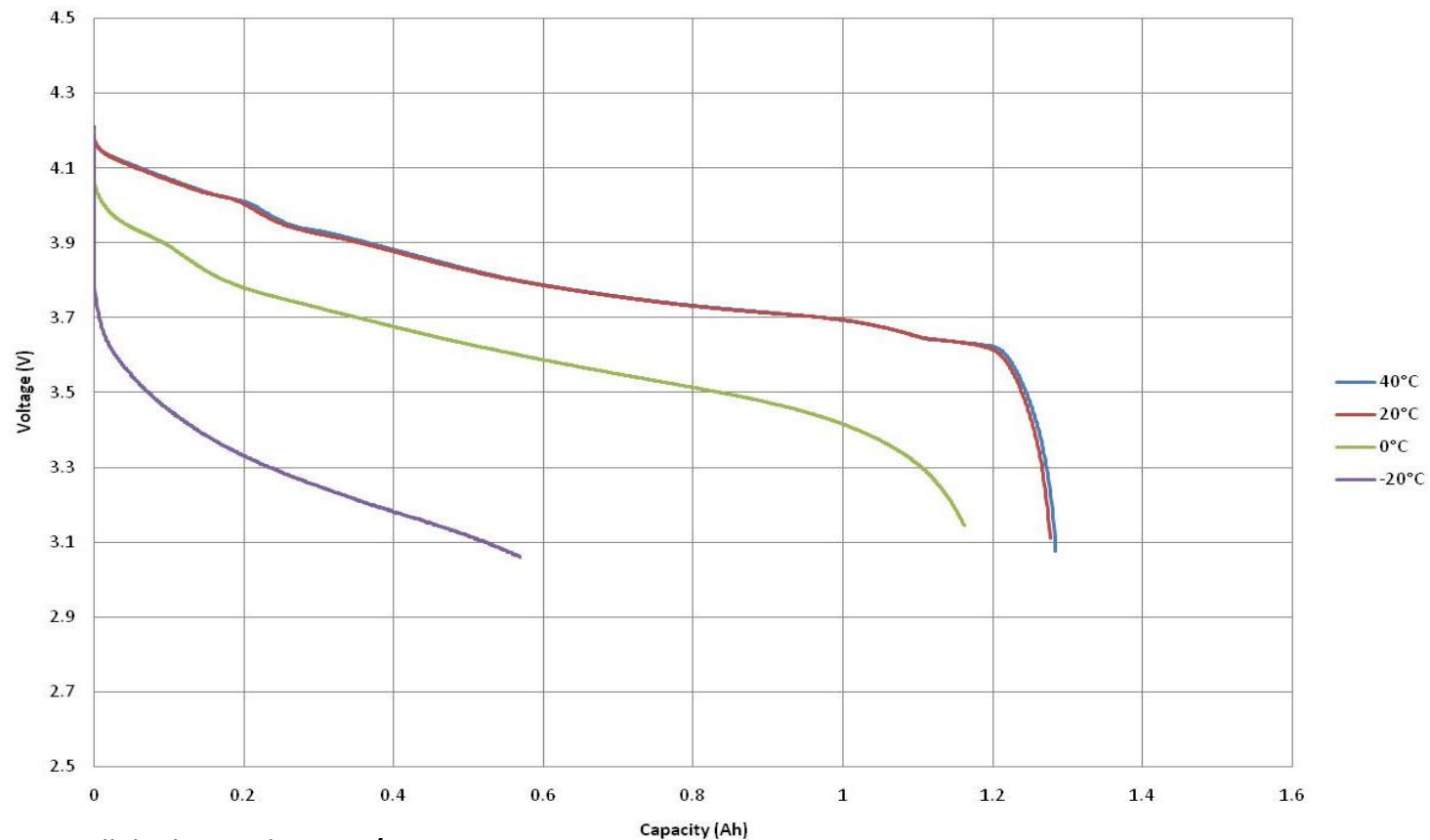
Cell Characterisation Tests: Discharge Plots at Different Rates and Temperatures

Cells tested at C/15, C/10, C/5, C/2 and C rates, at 40°C, 20°C, 0°C and -20°C



Cell discharge plots at **C/15**
at all temperatures

Cell Characterisation Tests: Discharge Plots at Different Rates and Temperatures



Cell discharge plots at **C/5**
at all temperatures

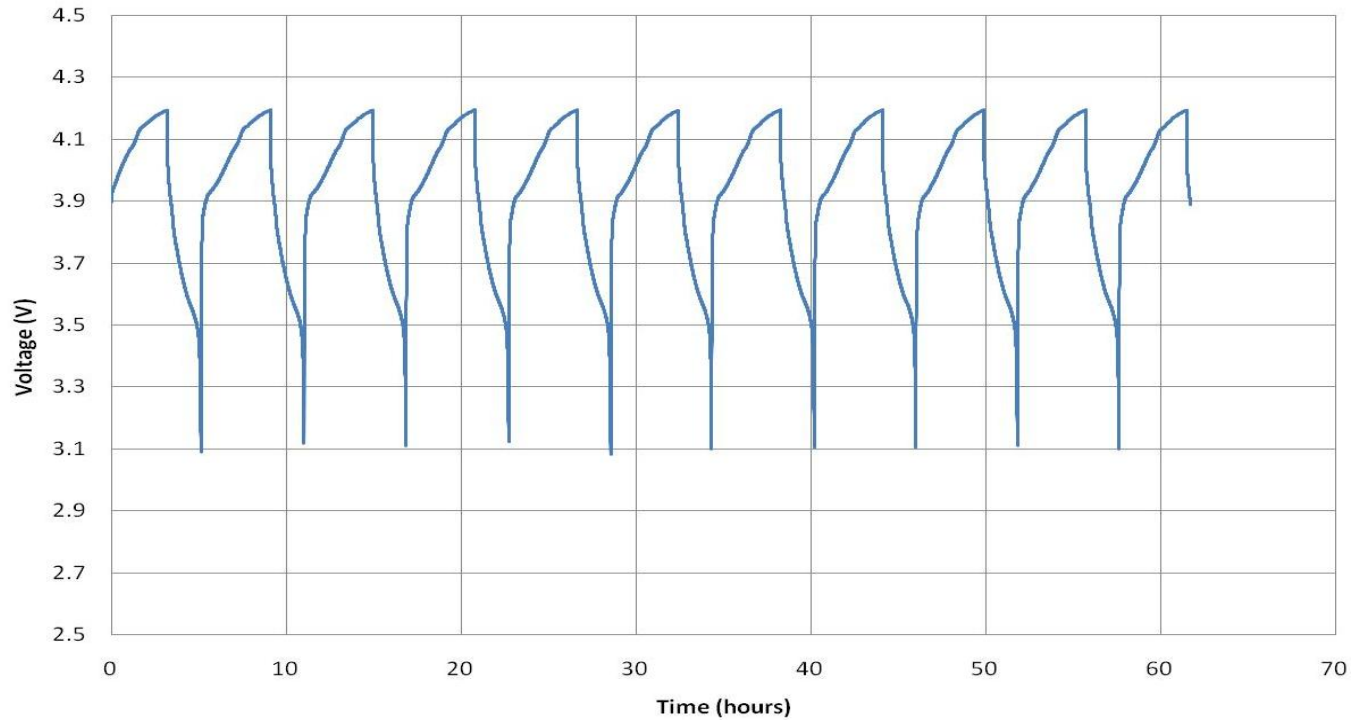
Largest difference in capacity before and after testing was for **-20°C** tests, with a **3.2%** decrease.

Cell Characterisation Tests

Vacuum Cycling



C/2 rate, 20°C, 19mbar vacuum



Capacity, C/2, ambient pressure = **1.226Ah**
Capacity, C/2, 19mbar pressure, cycle 1 = **1.193Ah**
cycle 10 = **1.187Ah**

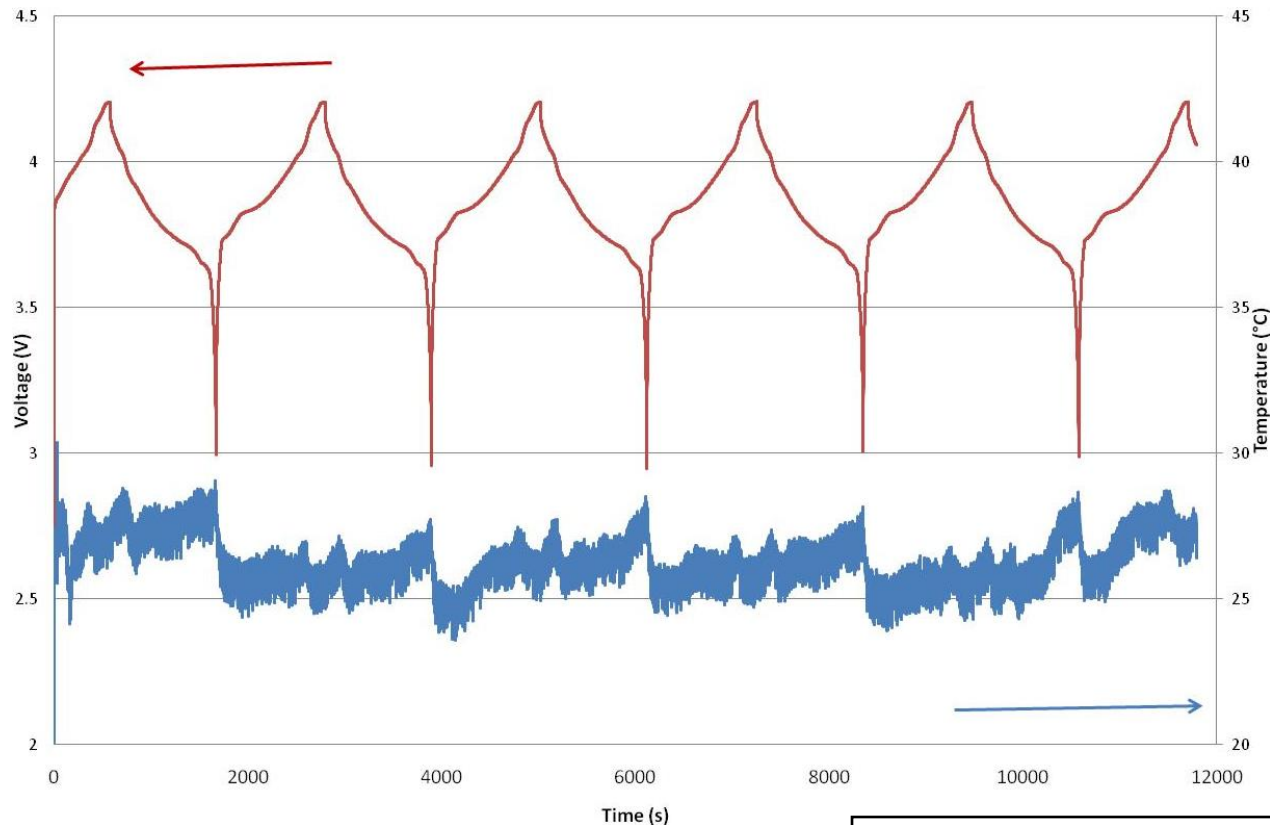
0.5% decrease in capacity
between cycle 1 and cycle 10.

Cell Balancing and Thermal Properties

Cell Skin Temperature Variation with Cycling



8 cell string, C/5 charge/discharge rate, 20°C



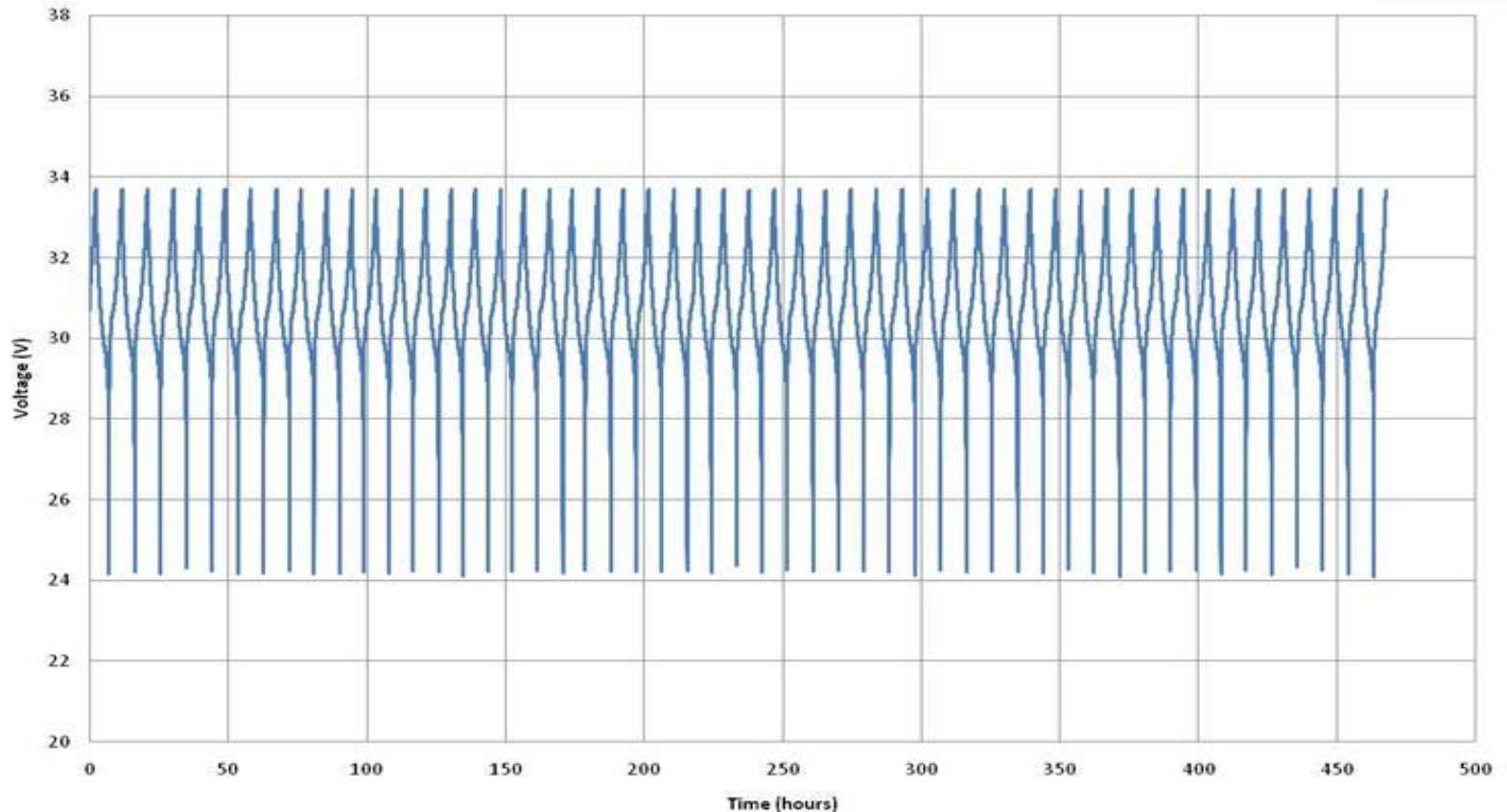
Maximum Temperature = 29.03°C
Minimum Temperature = 23.57°C

Cell Balancing and Thermal Properties

Cycling of 8 Cell String



50 cycles at C/5 charge/discharge rate, 20°C



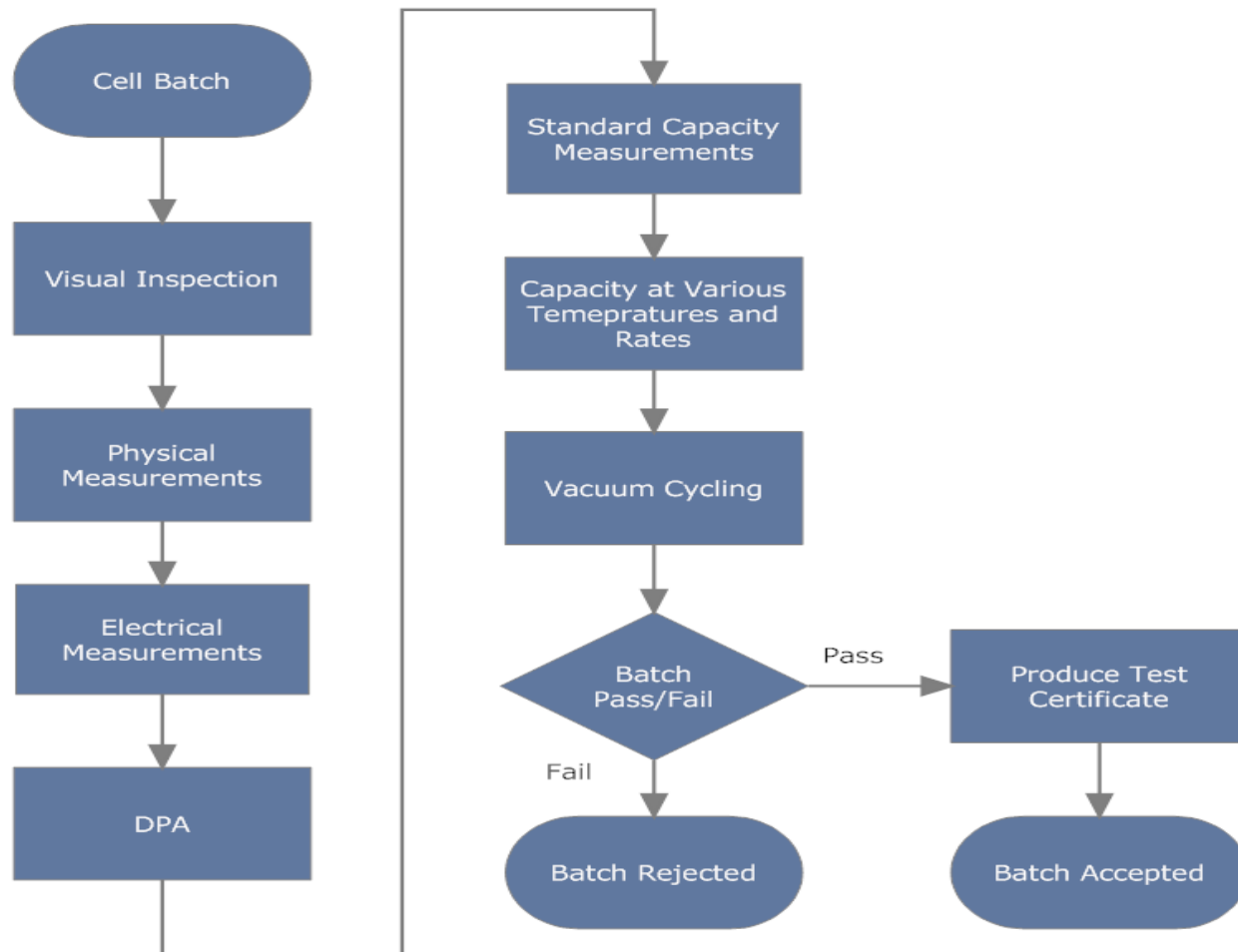
Lowest end of discharge cell voltage = **2.641V**

Absolute minimum voltage which a lithium ion cell can be discharged to is 2.5V

Largest drop in capacity after 50 cycles at C/5 was **0.4%**

Largest difference in cell voltages at end of discharge = **0.59V**

Lot Acceptance Test Procedure



Cell Matching Procedure



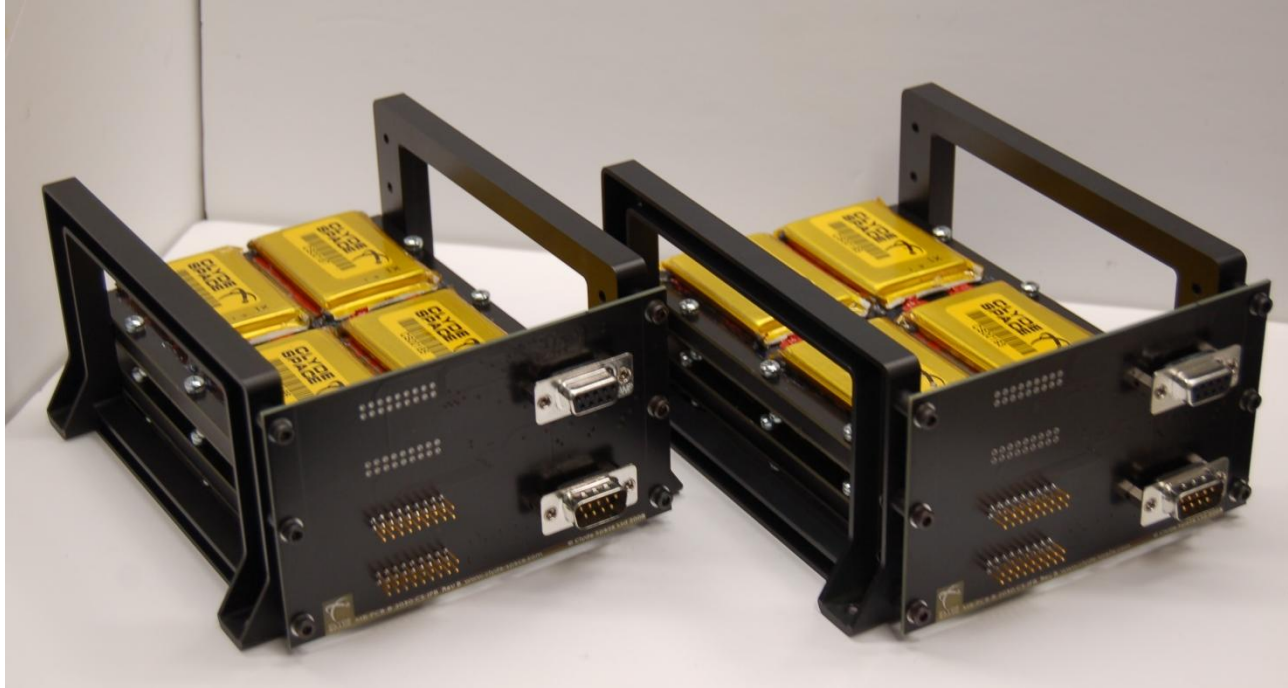
- Batch passed LOT Acceptance Procedure
- Perform standard capacity measurements on each cell (4.2V – 3V at C/5)
- Cells placed into groups according to measured capacity, varying by no more than 3% within group
- Strings of cells will be constructed of cells from only one group.

Modular Battery Design



- 5Ah at 30V nominal
- Integrated thermostatically controlled heater
- Temperature, Voltage and Current Telemetries
- Range of communication formats possible; I2C, CAN, and SPI
- Modular Design, so 2.5Ah, 5Ah, 10Ah versions possible just by altering frame size.

Life Testing



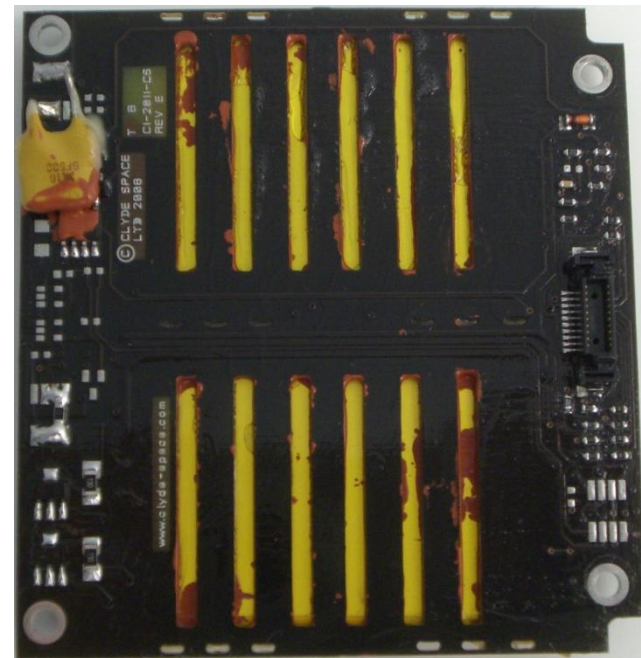
Two 8s2p batteries to undergo life testing at ESTEC

LEO conditions, 20°C, hard vacuum, to 10% and 25% DoD respectively

Clyde Space CubeSat Battery



- Two lithium Polymer Cells are connected in series, providing about **10Whrs** at **8.2V**
- Integrated thermostatically controlled heater
- Over/under voltage protection
- Over current protection (PTC device positioned on the battery board which can be easily replaced in case of short circuit)
- Voltage, Current and Temperature Telemetry
- Cell balancing circuitry



Thank You!

Have a look at our new website and online shop at
www.clyde-space.com

